Analysis of Air Quality Index in Delhi

Objective

1. To find the distribution of pollutants

2. To calculate AQI

3. See how often different air quality conditions occur.

4. Look at how air quality changes throughout the day to find the busiest pollution times.

5. Check if certain pollutants tend to rise or fall together, showing how they're connected.

[1]:
```
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

Importing Dataset

[2]:
```
data = pd.read_csv('delhiaqi.csv')
```

[3]:
```
data
```

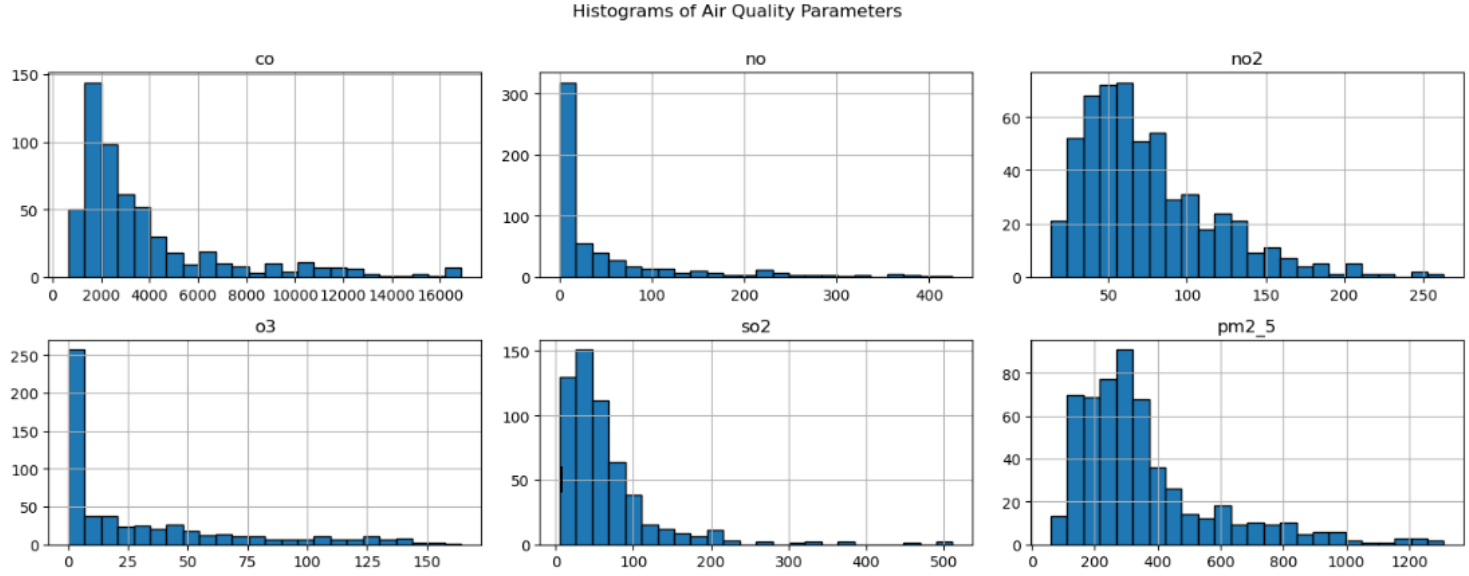
[3]:

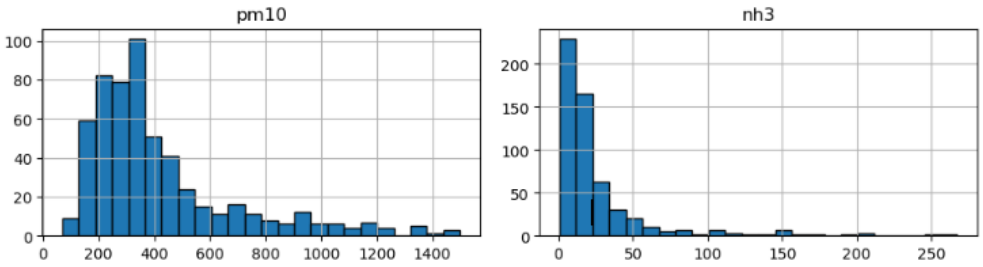
	date	co	no	no2	o3	so2	pm2_5	pm10	nh3
0	2023-01-01 00:00:00	1655.58	1.66	39.41	5.90	17.88	169.29	194.64	5.83
1	2023-01-01 01:00:00	1869.20	6.82	42.16	1.99	22.17	182.84	211.08	7.66
2	2023-01-01 02:00:00	2510.07	27.72	43.87	0.02	30.04	220.25	260.68	11.40
3	2023-01-01 03:00:00	3150.94	55.43	44.55	0.85	35.76	252.90	304.12	13.55
4	2023-01-01 04:00:00	3471.37	68.84	45.24	5.45	39.10	266.36	322.80	14.19
...	...	...	...	...	...	...	...	...	...
556	2023-01-24 04:00:00	1762.39	4.64	37.01	33.26	30.52	231.15	289.84	6.27
557	2023-01-24 05:00:00	1735.69	6.82	34.96	46.49	34.33	225.08	280.52	9.12
558	2023-01-24 06:00:00	1922.61	8.16	40.10	56.51	43.39	242.49	296.07	12.54
559	2023-01-24 07:00:00	1361.85	9.05	52.78	71.53	100.14	165.67	191.82	7.47
560	2023-01-24 08:00:00	1134.87	8.61	56.89	80.11	110.63	123.76	140.26	5.51

561 rows × 9 columns

Data Distribution of Pollutants

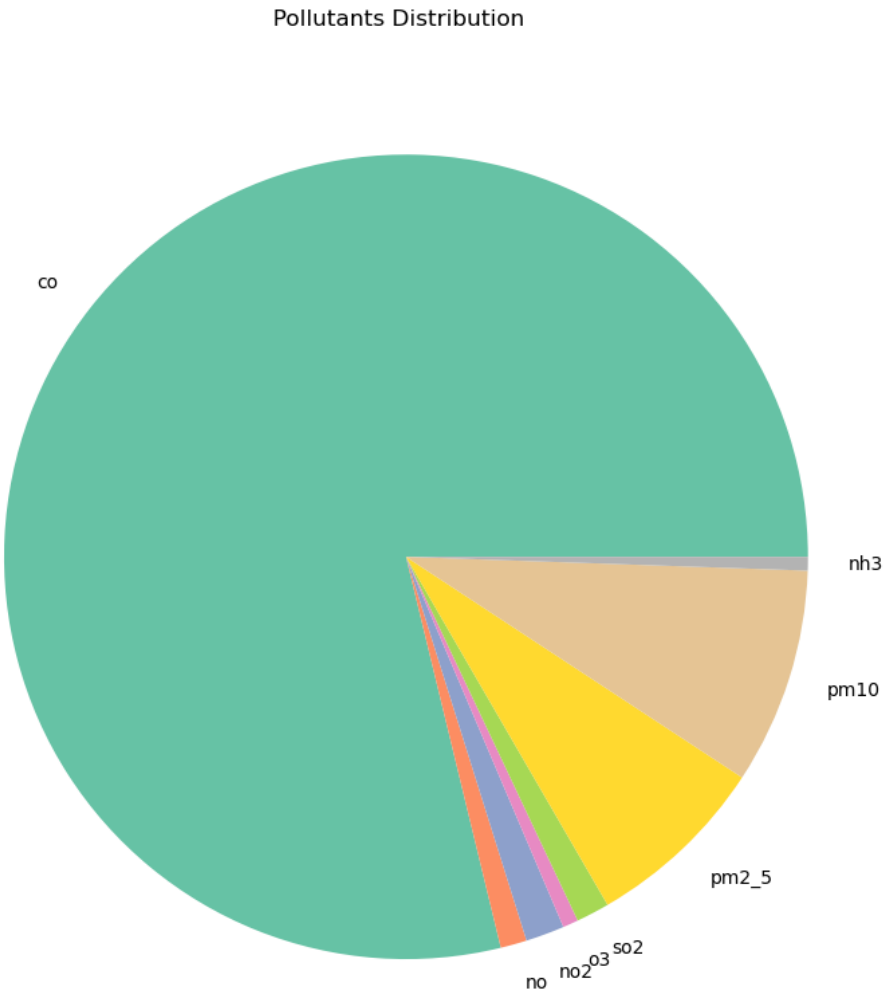
[4]:
```
features = data.drop(columns = ['date'])
features.hist(bins= 24, figsize=(14,8), edgecolor = 'black')
plt.suptitle('Histograms of Air Quality Parameters', y = 1)
plt.tight_layout()
sns.set_palette('Set2')
plt.show()
```





[5]:
```
values = data[['co','no','no2','o3','so2','pm2_5','pm10','nh3']].sum(axis=0)
pollutants = list(['co','no','no2','o3','so2','pm2_5','pm10','nh3'])
```

[6]:
```
sns.set_palette('Set2')
plt.figure(figsize =(12,8))
plt.pie(values, labels = pollutants)
plt.title('Pollutants Distribution')
plt.tight_layout()
```



Carbon Monoxide (CO) makes up the biggest part of the pollution, about 69%.

Air Quality Index

[7]:
```
co_breakpoints = [(0, 1, 0, 50), (1.01, 2, 51, 100), (2.01, 10, 101, 200),
(10.01, 17, 201, 300), (17.01, 34, 301, 400), (34.01, 999999, 401, 500)]

no2_breakpoints = [(0, 40, 0, 50), (41, 80, 51, 100), (81, 180, 101, 200),
(181, 280, 201, 300), (281, 400, 301, 400), (401, 999999, 401, 500)]

no_breakpoints = no2_breakpoints

o3_breakpoints = [(0, 50, 0, 50), (51, 100, 51, 100), (101, 168, 101, 200),
(169, 208, 201, 300), (209, 748, 301, 400), (749, 999999, 401, 500)]

so2_breakpoints = [(0, 40, 0, 50), (41, 80, 51, 100), (81, 380, 101, 200),
(381, 800, 201, 300), (801, 1600, 301, 400), (1601, 999999, 401, 500)]

pm25_breakpoints = [(0, 30, 0, 50), (31, 60, 51, 100), (61, 90, 101, 200),
(91, 120, 201, 300), (121, 250, 301, 400), (251, 999999, 401, 500)]

pm10_breakpoints = [(0, 50, 0, 50), (51, 100, 51, 100), (101, 250, 101, 200),
(251, 350, 201, 300), (351, 430, 301, 400), (431, 999999, 401, 500)]

nh3_breakpoints = [(0, 200, 0, 50), (201, 400, 51, 100), (401, 800, 101, 200),
(801, 1200, 201, 300), (1201, 1800, 301, 400), (1801, 999999, 401, 500)]
```

[8]:
```
def calculate_sub_index(concentration, breakpoints):
    for (low_conc, high_conc, low_index, high_index) in breakpoints:
        if low_conc <= concentration <= high_conc:
            return low_index + (high_index - low_index)/(high_conc - low_conc)*(concentration - low_conc)
    return 500
```

[9]:
```
ugm3_to_mgm3 = 1e-3
```

[10]:
```
def calculate_aqi(row):
    row['pm2_5_sub_index'] = calculate_sub_index(row['pm2_5'], pm25_breakpoints)
    row['pm10_sub_index'] = calculate_sub_index(row['pm10'], pm10_breakpoints)
    row['no2_sub_index'] = calculate_sub_index(row['no2'], no2_breakpoints)
    row['o3_sub_index'] = calculate_sub_index(row['o3'], o3_breakpoints)
    row['co_sub_index'] = calculate_sub_index(row['co'] * ugm3_to_mgm3, co_breakpoints)  # Convert from µg/m³ to mg/m³
    row['so2_sub_index'] = calculate_sub_index(row['so2'], so2_breakpoints)
    row['nh3_sub_index'] = calculate_sub_index(row['nh3'], nh3_breakpoints)
    row['no_sub_index'] = calculate_sub_index(row['no'], no_breakpoints)

    aqi = max(row['pm2_5_sub_index'], row['pm10_sub_index'], row['no2_sub_index'],
              row['o3_sub_index'], row['co_sub_index'], row['so2_sub_index'],
              row['nh3_sub_index'], row['no_sub_index'])
    return aqi
```

[11]:
```
data['AQI'] = data.apply(calculate_aqi, axis = 1)
data.head()
```

[11]:

	date	co	no	no2	o3	so2	pm2_5	pm10	nh3	AQI
0	2023-01-01 00:00:00	1655.58	1.66	39.41	5.90	17.88	169.29	194.64	5.83	338.059767
1	2023-01-01 01:00:00	1869.20	6.82	42.16	1.99	22.17	182.84	211.08	7.66	348.458605
2	2023-01-01 02:00:00	2510.07	27.72	43.87	0.02	30.04	220.25	260.68	11.40	377.168605
3	2023-01-01 03:00:00	3150.94	55.43	44.55	0.85	35.76	252.90	304.12	13.55	401.000188
4	2023-01-01 04:00:00	3471.37	68.84	45.24	5.45	39.10	266.36	322.80	14.19	401.001521

[12]:
```
aqi_categories = {
    (0, 50): 'Good',
    (51, 100): 'Satisfactory',
    (101, 200): 'Moderately polluted',
    (201, 300): 'Poor',
    (301, 400): 'Very Poor',
    (401, 500): 'Severe'
}
```

.

[13]:
```
def get_aqi_category(aqi):
    for (low_aqi, high_aqi), category in aqi_categories.items():
        if low_aqi <= aqi <= high_aqi:
            return category
    return 'Severe'
```

[14]:
```
data['AQI_Category'] = data['AQI'].apply(get_aqi_category)
aqi_category_distribution =data['AQI_Category'].value_counts(normalize = True) * 100
aqi_category_distribution
```

[14]:
```
AQI_Category
Severe                67.557932
Very Poor             29.768271
Poor                   1.960784
Moderately polluted    0.713012
Name: proportion, dtype: float64
```

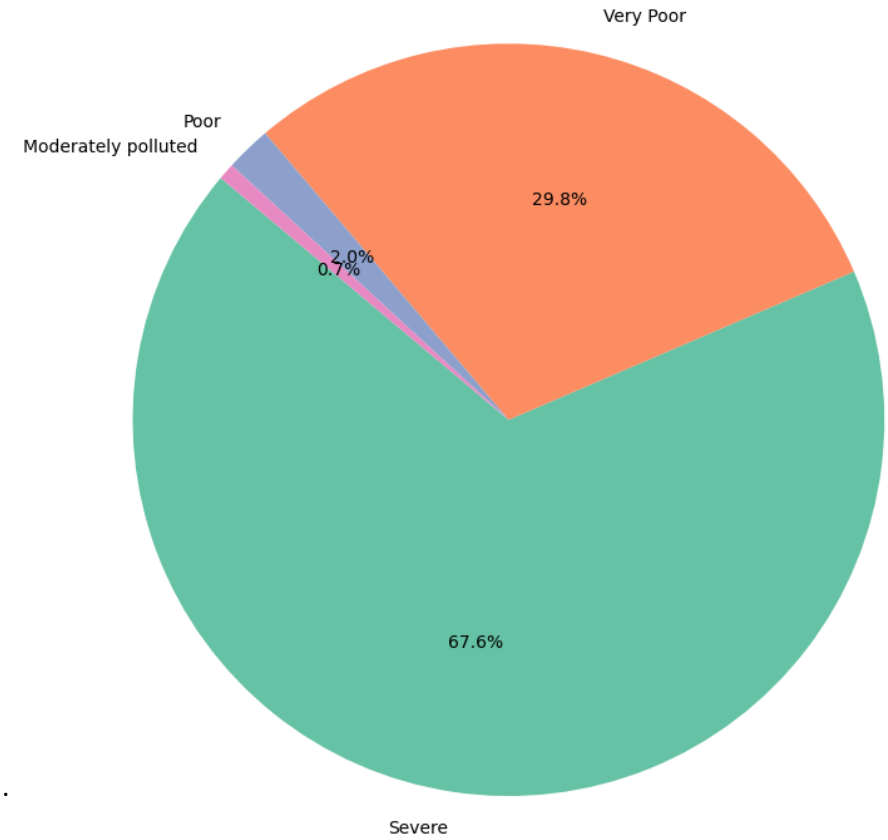
[15]:
```
data['date']= pd.to_datetime(data['date'])
data['hour']= data['date'].dt.hour
hourly_aqi= data.groupby('hour')['AQI'].mean()
```

[16]:
```
data.head()
```

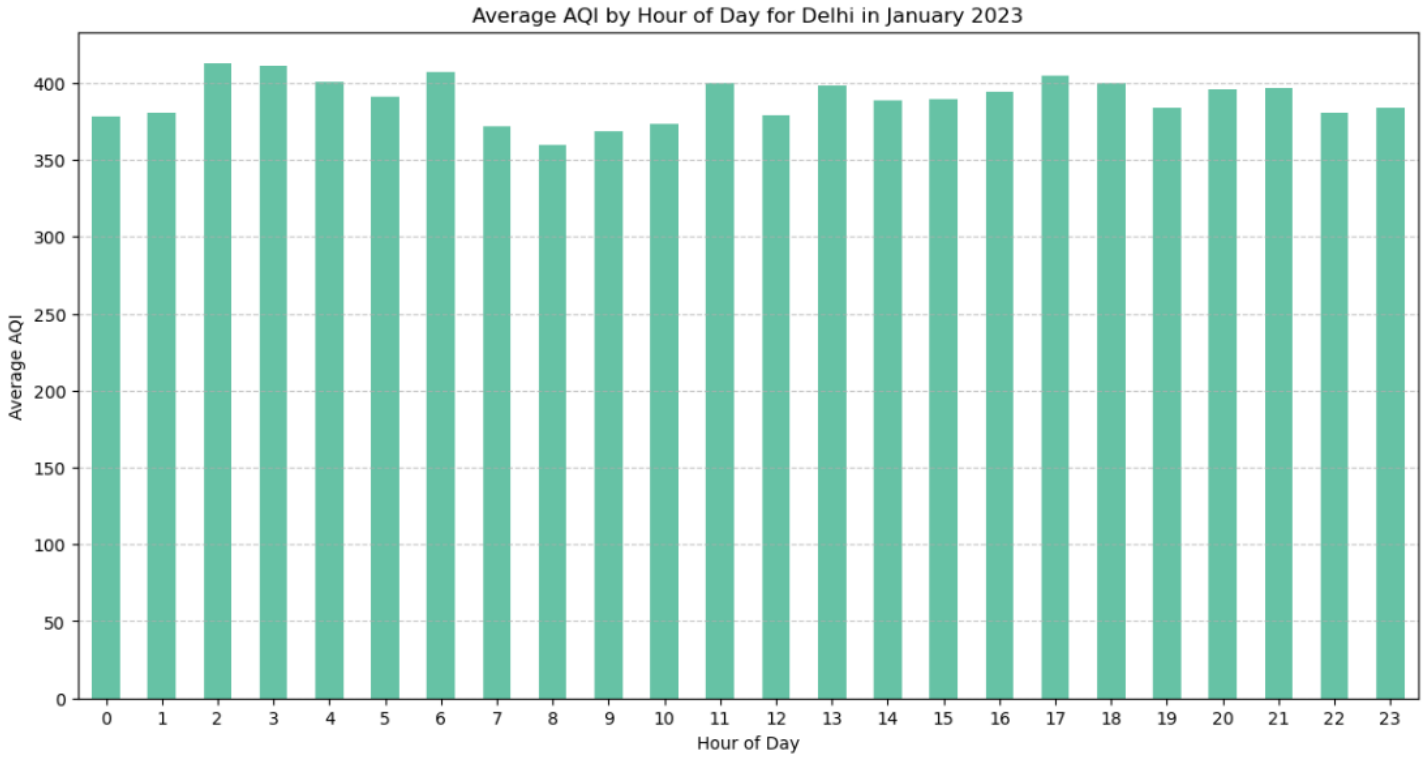
[16]:

	date	co	no	no2	o3	so2	pm2_5	pm10	nh3	AQI	AQI_Category	hour
0	2023-01-01 00:00:00	1655.58	1.66	39.41	5.90	17.88	169.29	194.64	5.83	338.059767	Very Poor	0
1	2023-01-01 01:00:00	1869.20	6.82	42.16	1.99	22.17	182.84	211.08	7.66	348.458605	Very Poor	1
2	2023-01-01 02:00:00	2510.07	27.72	43.87	0.02	30.04	220.25	260.68	11.40	377.168605	Very Poor	2
3	2023-01-01 03:00:00	3150.94	55.43	44.55	0.85	35.76	252.90	304.12	13.55	401.000188	Severe	3
4	2023-01-01 04:00:00	3471.37	68.84	45.24	5.45	39.10	266.36	322.80	14.19	401.001521	Severe	4

[42]:
```
category_counts = data['AQI_Category'].value_counts()

plt.figure(figsize=(12,8))
plt.pie(category_counts, labels=category_counts.index, autopct='%1.1f%%', startangle=140)
plt.title('Distribution of AQI Categories')
plt.tight_layout()
sns.set_palette('Set2')
plt.show()
```

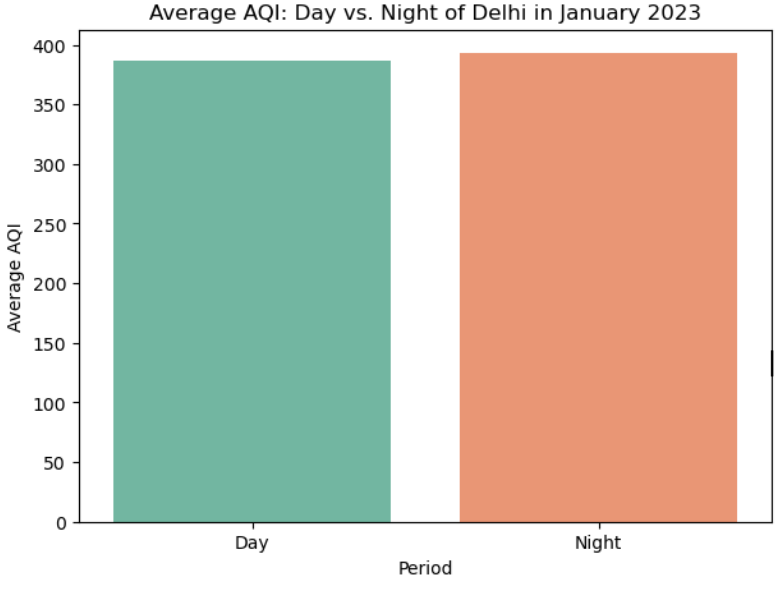


[17]:
```
plt.figure(figsize=(14, 7))
hourly_aqi.plot(kind='bar')
plt.title('Average AQI by Hour of Day for Delhi in January 2023')
plt.xlabel('Hour of Day')
plt.ylabel('Average AQI')
plt.xticks(rotation=0)
plt.grid(axis='y', linestyle='--', alpha=0.7)
sns.set_palette('Set2')
plt.show()
```

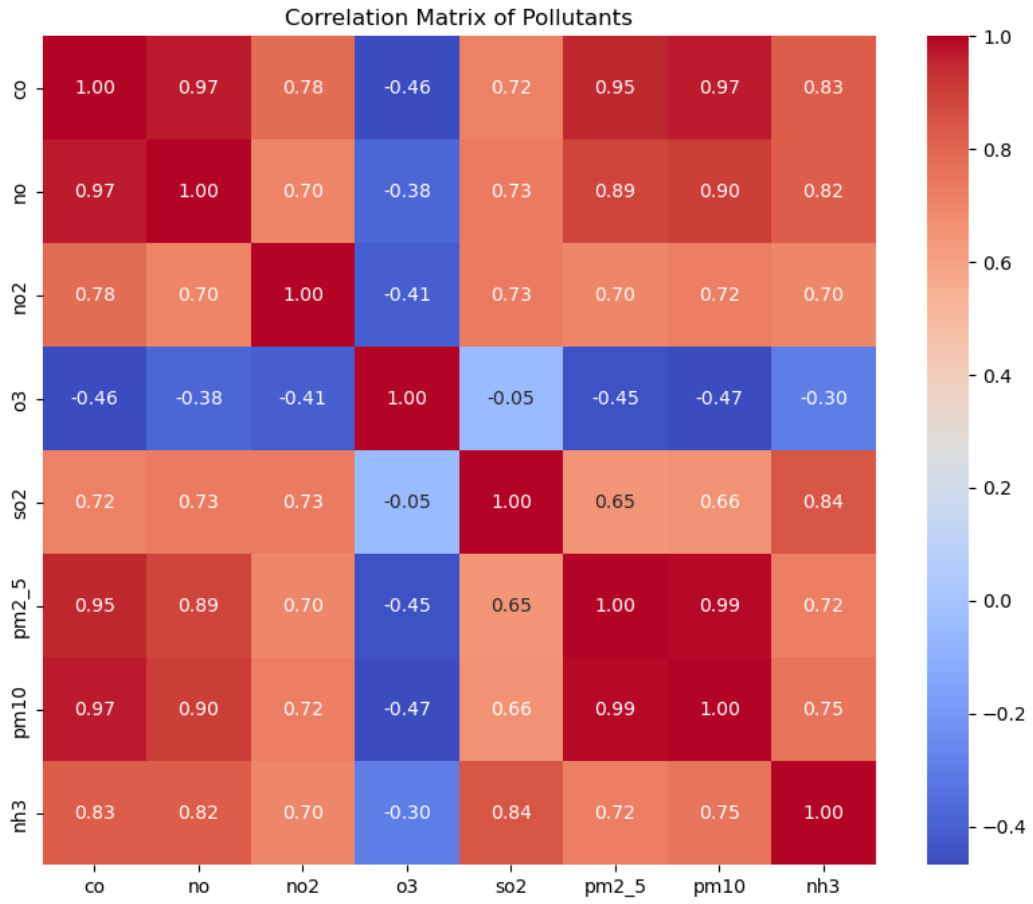


[18]:
```
day_hours = (6,18)
night_hours = (18,6)

daytime_data = data[(data['hour'] >= day_hours[0]) & (data['hour'] < day_hours[1])]
nighttime_data = data[(data['hour'] >= night_hours[0]) | (data['hour'] < night_hours[1])]

average_day_aqi = daytime_data['AQI'].mean()
average_night_aqi = nighttime_data['AQI'].mean()
day_night_aqi_comparison = pd.DataFrame({
    'Period': ['Day', 'Night'],
    'Average AQI': [average_day_aqi, average_night_aqi]
})
```

[24]:
```
plt.figure(figsize=(7, 5))
sns.barplot(x='Period', y='Average AQI', data=day_night_aqi_comparison)
plt.title('Average AQI: Day vs. Night of Delhi in January 2023')
plt.ylabel('Average AQI')
sns.set_palette('Set2')
plt.show()
```



[28]:
```
pollutants = ['co', 'no', 'no2', 'o3', 'so2', 'pm2_5', 'pm10', 'nh3']
correlation_matrix = data[pollutants].corr()

plt.figure(figsize=(10, 8))
plt.title('Correlation Matrix of Pollutants')
sns.heatmap(correlation_matrix, annot=True, cmap='coolwarm', fmt=".2f", cbar=True)
plt.show()
```



Findings

Air Quality Levels:

"Very Poor" and "Severe" categories: 97.33% of the time

"Good" and "Satisfactory" categories: 2.67% of the time

Hourly Trends:

Average AQI at night: 393.01

Average AQI during the day: 386.26

Daily Extremes:

Highest daily AQI: 421.63

Lowest daily AQI: 330.37

Pollutant Relationships:

Strong correlations found between certain pollutants, indicating shared sources or similar dispersion patterns.

Specific Strategies for Reducing Carbon Monoxide (CO) Levels:

Vehicle Emission Controls:

Enforce stringent vehicle emission standards and promote the use of cleaner fuels like CNG and EVs.

Traffic Management:

Optimize traffic flow, encourage carpooling and public transportation, and discourage vehicle idling.

Industrial Regulations:

Implement strict emissions regulations for factories and power plants, and adopt pollution control measures.

Urban Planning:

Design cities with mixed land-use, pedestrian-friendly infrastructure, and green spaces to reduce commuting and CO emissions.

General Strategies for Overall Air Quality Improvement:

Renewable Energy Promotion:

Transition to renewable energy sources such as solar and wind power.

Green Building Standards:

Implement green building codes focusing on energy efficiency and proper ventilation.

Waste Management:

Promote efficient waste management practices like recycling and composting.

Afforestation and Urban Greening:

Plant trees, create green spaces, and establish urban forests to absorb pollutants and mitigate the urban heat island effect.

Public Awareness and Education:

Educate the public about air quality importance and promote eco-friendly behaviors.

Cross-Sector Collaboration:

Foster collaboration among stakeholders to develop comprehensive air quality management plans and monitor progress.